Investigating $H_2{}^{14}O$ and ${}^{10}CO_2$ as cerebral blood flow tracers in PET

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Functional brain mapping with positron emission tomography (PET) is limited largely by exam time, mainly waiting between subsequent injections for the prior dose to decay. This time can be reduced by using a shorter-lived isotope than the commonly used oxygen-15 ($ß^+$, 122 second half life). Two alternative isotopes have been developed. These isotopes, oxygen-14 ($ß^+$, 2314 keV gamma, 71 second half life) and carbon-10 ($ß^+$, 719 keV gamma, 19 second half life), hold the promise of increasing study repetition rate by a factor of 2-5.

Production targetry for ${}^{10}C$ and ${}^{14}O$ were developed for an 11.4 MeV, 6-8 mm FWHM proton beam from the UW cyclotron. ${}^{14}O$ is produced via the ${}^{14}N(p,n){}^{14}O$ reaction in a 99.5% N_2 0.5% O_2 flow through target, and ${}^{10}C$ is produced by bombarding enriched ${}^{10}B_2O_3$ via the ${}^{10}B(p,n){}^{10}C$ reaction. Extraction of the ${}^{10}C$ from the boric oxide melt is strongly temperature dependent, and evidence is presented indicating that this extraction is greatly aided by convection. Both isotopes were converted to CO_2 in high-speed flow-through chemistry, and the radiochemical purity of the final product was measured.

The dosimetry of these short lived blood flow tracers was calculated with computer simulation. Where possible the calculated results were compared to measured and calculated values in the literature, and show good agreement. This study shows that both ${}^{14}O$ and ${}^{10}C$ suffer dosimetrically from their gamma rays, but this is offset by their greater study repetition rates.

The effects of the prompt gamma rays of ${}^{14}O$ and ${}^{10}C$ on image degradation were explored on a variety of PET scanners, in both 2D and 3D phantom studies. These data show minimal effect in the final image quality. This is born out by human imaging, performed at the Rigshospitalet in Copenhagen, Denmark.